

**Reversible axial piston machine  
with longitudinal adjustment**

The invention relates to a reversible axial piston machine  
5 having an adjusting device for adjusting the pivot angle of  
a pivot balance of the reversible axial piston machine in  
both pivotal directions.

The volume of hydraulic fluid delivered in a rotation of  
10 the drive shaft of an axial piston machine is dependent on  
the stroke length of the cylinders arranged in a cylinder  
drum of an axial piston machine during a compression or  
suction procedure. The stroke length is set by inclined  
points of the inclined surface of a pivot balance, on which  
15 the individual cylinders are supported during their  
rotational movement about the drive axis, in relation to  
the axial alignment of the drive axis. The control angle of  
the inclined surface with respect to the axial alignment of  
the drive axis is adjusted by an adjusting device.

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For axial piston machines which are operated in both  
pivotal directions - reversible axial piston machines -  
positive and negative adjustment angles have to be set at  
the pivot balances.

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In principle, there are two embodiments for the arrangement  
of the adjusting device in relation to the arrangement of  
the drive axis of the axial piston machine. In the case of  
transverse adjustment, the adjusting device executes a  
30 translatory movement for adjusting the pivot balance  
transversely to the arrangement of the drive axis of the  
axial piston machine. In the case of longitudinal  
adjustment, the adjusting device executes a translatory

movement for adjusting the pivot balance in the longitudinal direction of the drive axis of the axial piston machine. When taking into account structural considerations - for example when using the axial piston  
5 machine in mobile concrete mixers - longitudinal adjustment is preferred over transverse adjustment since this has a smaller overall volume.

A not insignificant problem with adjusting devices is the  
10 precise setting of the zero position. If, in the uncontrolled operating condition of the adjusting device, no control pressure is applied for example to a pressure-controlled adjusting device (unpressurised operating condition), the adjustment angle of the pivot balance is  
15 precisely zero degrees when the set zero position of the adjusting device is set correctly. In this case, the inclined surface is precisely perpendicular to the longitudinal axis of the drive shaft. None of the pistons in any of the cylinders of the cylinder drum is able to  
20 execute a stroke movement here.

DE 37 14 888 A1 illustrates a reversible axial piston machine having an adjusting device which operates according to the variant with longitudinal adjustment. The zero  
25 position of the pivot balance in the uncontrolled operation of the axial piston machine is non-adjustable and is undefined. In this axial piston machine, the adjustment angle which is actually set at the pivot balance does not, therefore, generally correspond precisely to the  
30 predetermined adjustment angle. The actual displacement volume therefore generally deviates from the predetermined displacement volume.

The object of the invention, therefore, is to further develop the reversible axial piston machine with longitudinal adjustment according to the features in the precharacterising clause of Claim 1 in such a way that there is definitely no presence of displacement volume in the uncontrolled condition.

The object of the invention is achieved by a reversible axial piston machine having the features of Claim 1.

According to the invention, to set the zero position in the pivot balance, a zero-position setting device is provided in the adjusting device according to Claim 1. The advantage of this zero-position setting device is that the zero position of the inclined surface can be set precisely and without play in the uncontrolled operation of the axial piston machine.

Advantageous, and particularly detailed, constructions of the invention are described in the dependent claims.

A further advantage of the zero-position setting device can be seen in the use of a single pressure spring which is tensioned between two spring plates on the adjusting rod and acts on the control piston, which is displaceable in the adjusting device, in both control directions with the same pretension force. In the adjustment procedure for determining the zero position, it is thus possible to position the control piston, and the pivot balance which is coupled to the control piston by way of a form-fitting attachment, in both control or pivotal directions by means

of a pretension force defined by the spring constant of the pressure spring. This means that there is no need to carry out a complex procedure for ensuring that the spring constants, and therefore the pretension forces, of two  
5 opposingly acting pressure springs, which in applications of this type normally each generate a pretension force for one adjusting device, are equally matched.

The claimed reversible axial piston machine and the  
10 associated adjusting device is furthermore advantageous in that the adjustment travel of the control piston or the adjustment angle of the pivot balance can be adjustably delimited by way of a second adjusting rod, which is likewise guided out of the adjusting device or the axial  
15 piston machine.

Finally, the claimed adjusting device is advantageous in that, owing to its hollow cylindrical construction, the control piston, the zero-position setting device and other  
20 components located within the hollow cylinder of the adjusting device can be assembled and dismantled in relatively simple manner.

An exemplary embodiment of the invention is illustrated in  
25 the drawing and will be described in more detail below. The drawing shows:

Fig. 1 a cross-sectional illustration of an axial piston  
machine according to the invention, with an  
30 adjusting device according to the invention;

Fig. 2 a cross-sectional illustration of an adjusting device according to the invention;

Fig. 3 a cross-sectional illustration of a further embodiment of the adjusting device according to the invention; and

Fig. 4 a three-dimensional view of an axial piston machine according to the invention, with an adjusting device according to the invention connected by way of a form-fitting attachment.

The reversible axial piston machine according to the invention and the adjusting device according to the invention are described in both their embodiments below with reference to Fig. 1 to Fig. 4.

Fig. 1 shows a cross-section of a reversible axial piston machine 1 according to the invention. This comprises a drive shaft 4 mounted in an axially aligned cutout 2 of the housing 3. Arranged in rotationally fixed manner on the drive shaft 4, there is a cylinder drum 5 in which a plurality of cylinder cutouts are arranged at equal mutual spacings from one another on a circle which is concentric with the longitudinal axis 7 of the drive shaft 4.

Displaceably guided in each of the cylinder cutouts, there is a piston 6 which has, on its end opposite the cylinder chamber, a spherical head which is pivotably mounted in a guide shoe and supported against an inclined surface 8.

In relation to a zero-position axis 10, which is aligned at a right angle to the axis of rotation 7 of the cylinder

drum 5, the pivot balance 9, and with it the inclined surface 8, is pivotable through a positive adjustment angle  $\alpha_1$  and negative adjustment angle  $\alpha_2$  with respect to the zero-position axis 10.

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The adjusting device 12, whereof the cross-section - in addition to the illustration in Fig. 1 - is also illustrated on a slightly enlarged scale in Fig. 2, comprises a hollow cylinder 13 which serves as a housing and has a first step 14. The first opening 15 in the hollow cylinder 13, which faces the pivot balance 9, is not closed and enables a control piston 16 guided in the hollow cylinder 13 to be displaced at least partially out of the inner region 17 of the hollow cylinder 13. The second opening 18 of the hollow cylinder 13, which is opposite the first opening 15, is closed by a closing cover 19.

The closing cover 19 has an annular web 20. The external diameter of the annular web 20 of the closing cover 19 corresponds to the internal diameter of the hollow cylinder in the region between the first step 14 and the second opening 18. The internal diameter of the annular web 20 of the closing cover 19 corresponds to the internal diameter of the hollow cylinder 13 in the region between the first step 14 and the first opening 15. The closing cover 19 is guided into the interior 17 of the hollow cylinder 13 by means of an annular web 20 in such a way that a form-fitting connection is produced between the hollow cylinder 13 and the closing cover 19.

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Incorporated in the inner lateral surface 21 of the hollow cylinder 13, between the first opening 15 and the first

step 14, and also in the inner lateral surface 27 of the annular web 20 of the closing cover 19, there are annular grooves 22 in which guide rings 23, for example of brass, are arranged. These guide rings 23 serve as guide bearings  
5 for the control piston 24, which is mounted centrically to the longitudinal axis 11 in the interior 17 of the hollow cylinder 13 and is displaceable in the direction of the longitudinal axis 11.

10 The control piston 24 has a substantially hollow cylindrical geometry. At approximately half the cylinder height of the hollow cylindrical control piston 24, the control piston 24 has a flange-like widening 26 on its outer lateral surface 25. Since the width of this flange-  
15 like widening 26 corresponds to the width of the first step 14 of the hollow cylinder 13, the flange-like widening 26 of the control piston 24 is in contact with the inner lateral surface 27 of the hollow cylinder 13 between the first step 14 and the second opening 18.

20 The geometry of the control piston 24, the hollow cylinder 13 and the closing cover 19 in the region of the flange-like widening 26 of the control piston 24 results in the formation of a first control pressure chamber 28 and a  
25 second control pressure chamber 29 in the interior 17 of the hollow cylinder 13. The first side face 30 of the flange-like widening 26 of the control piston 24, which is connected to the first control pressure chamber 28, serves as a working surface for a control pressure which is guided  
30 through the first control pressure opening 31 in the wall of the hollow cylinder 13 and into the first control pressure chamber 28 for the purpose of displacing the

control piston 24 along its longitudinal axis 11 in the direction of the second opening 18 of the hollow cylinder 13. The second side face 32 of the flange-like widening 26 of the control piston 24, which is connected to  
5 the second control pressure chamber 29, serves as a working surface for a control pressure which is guided through the second control pressure opening 33 in the wall of the hollow cylinder 13 and into the second control pressure chamber 29 for the purpose of displacing the control  
10 piston 24 along its longitudinal axis 32 in the direction of the first opening 15 of the hollow cylinder 13.

To seal the first and second control pressure chambers 28 and 29 against hydraulic fluid, sealing rings 36 which are  
15 guided in grooves are provided in the region of the inner lateral surfaces 21 and 27 of the hollow cylinder 13, the inner lateral surface 22 and the outer lateral surface 34 of the annular web 20 of the closing cover 19 and the end face 35 of the flange-like widening 26 of the control  
20 piston 24.

The hollow cylindrical control piston 24 has a multi-stepped cutout 37 whereof the largest third opening 38 faces in the direction of the second opening 18 of the  
25 hollow cylinder 13. A first adjusting rod 39 is guided along the longitudinal axis 11 of the control piston 24 into the multi-stepped cutout 37. This first adjusting rod 39 is guided out of the adjusting device 12 by way of a bore 40 in the closing cover 19. By specifically screwing  
30 an adjusting nut 41 on the thread of the adjusting rod 39 outside the closing cover 19, the first adjusting rod 39 can be adjustably positioned in the adjusting device 12, in



the cavity 17 of the hollow cylinder 13 or in the cutout 37 of the control piston 24.

Fixed on the adjusting rod 39 in the region between the  
5 second step 42 and the third opening 38 of the cutout 37 of the control piston 24, there is a first spring plate 43 and a second spring plate 44. The first spring plate 43 is fixed on the adjusting rod 39 in that the pretension force of a pressure spring assembly 45 tensioned between the  
10 first spring plate 43 and the second spring plate 44 presses the spring plate 43 against the inside end face 46 of a closing flange 47 fixed to the internal hollow cylinder end of the adjusting rod 39. The second spring plate 44 is fixed on the adjusting rod 39 in that the  
15 pretension force of the pressure spring assembly 45 presses the spring plate 44 against a sleeve 48 fixed between the spring plate 44 and the closing cover 19 on the adjusting rod 39. The sleeve 48 has, on its inside, an annular groove in which an annular body 55 is fixed, which is arranged in  
20 a groove of the first adjusting rod 39 and is supported against the inside end face 46a of the groove arranged in the adjusting rod 39. The sleeve 48 and the position of the groove arranged in the adjusting rod could also be constructed according to a further embodiment illustrated  
25 in Fig. 3 so that the spring plate 44 is pressed directly against the annular body 55. In the exemplary embodiment, the pressure spring assembly 45 is composed of the two parallel-arranged pressure springs 45A and 45B, so that a compact construction can be achieved with the pressure  
30 spring assembly 45.

In addition to being fixed to the adjusting rod 39, a first spring plate 43 is in contact with the second step 42 of the cutout 37 of the control piston 24 by means of its end face 49 which is remote from the pressure spring assembly 5 45. By means of its end face 50 which is remote from the pressure spring assembly 45, the second spring plate 44 is in contact with a snap ring 51 arranged in the vicinity of the third opening 38 in an annular groove on the inner side face of the cutout 37 of the control piston 24.

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A second adjusting rod 52, which is guided into the interior 17 of the hollow cylinder 13 by way of a bore 53 in the closing cover 19, serves as an adjustable delimitation for the adjustment travel of the control 15 piston 24 along its longitudinal axis 32. The position of the second adjusting rod 52 within the interior 17 of the hollow cylinder 13 can be altered by screwing an adjusting nut 54 in defined manner on the thread of the second adjusting rod 52 outside the closing cover 19.

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The pivot balance 19 is adjusted in the direction of a positive adjustment angle  $\alpha_1$  to effect a zero-point adjustment by positioning the first adjusting rod 39 in the direction of the second opening 18 of the hollow cylinder 25 13 by means of actuating the first adjusting screw 41. The zero-point setting device 32, comprising the first adjusting rod 19, the pressure spring assembly 45, the first spring plate 43, the second spring plate 44 and the sleeve 48, is thus displaced in the direction of the second 30 opening 18 of the hollow cylinder 13. The force required for this displacement is transmitted from the closing flange 47 of the adjusting rod 39, which is moved in the

direction of the second opening 18 of the hollow cylinder 13, by way of its inside end face 46 to the first spring plate 43, from the first spring plate 43 to the pressure spring assembly 45, from the pressure spring assembly 45 to  
5 the second spring plate 44 and finally from the second spring plate 44 to the snap ring 51 which, fixed with form fit to the control piston 24, displaces the control piston 24 in the direction of the second opening 18.

10 The pivot balance 19 is adjusted in the direction of a negative adjustment angle  $\alpha_2$  to effect a zero-point adjustment by positioning the first adjusting rod 39 in the direction of the first opening 15 of the hollow cylinder 13 by means of actuating the first adjusting screw 41. The  
15 zero-point setting device 32 is thus displaced in the direction of the first opening 15 of the hollow cylinder 13. In this case, the force is transmitted from the sleeve 48, which is moved by way of the annular body 55 with the first adjusting rod 39 in the direction of the  
20 first opening 15 of the hollow cylinder 13, to the second spring plate 44, from the second spring plate 44 to the pressure spring assembly 45, from the pressure spring assembly 45 to the first spring plate 43 and finally from the first spring plate 43 to the second step 42 of the  
25 cutout 37 of the control piston 24. The transmission of the force to the control piston 24 effects a displacement of the control piston 24 in the direction of the first opening 15 of the hollow cylinder 13.

30 In addition to the damped force transmission from the first adjusting rod 39 to the control piston 24 within the framework of the zero-point adjustment of the pivot

balance 9, the predominant task of the pressure spring assembly 45 is that of generating a spring force which is proportional to the excursion of the control piston 24 and which counteracts the control force triggering the  
5 movement. This restoring spring force is identical for both displacement directions of the control piston 24 owing to the use of a single pressure spring assembly 45. The spring force of the pressure spring assembly 45 also has a defined value in the zero position of the pivot balance 9 since the  
10 pressure spring assembly 45 is held pretensioned between the first spring plate 43 and the second spring plate 44 in each of the positions of the control piston 24.

If the control pressure which is guided through the first  
15 control pressure opening 31 into the first control pressure chamber 28 and acts on the first side wall 30, serving as the working surface, of the flange-like widening 26 is greater than the control pressure which is guided through the second control pressure opening 33 into the second  
20 control pressure chamber 29 and acts on the second side wall 32, serving as the working surface, of the flange-like widening 26, then the control piston 24 is displaced in the direction of the second opening 18 of the hollow cylinder 13. As a result of the displacement of the control  
25 piston 24 in the direction of the second opening 18 of the hollow cylinder 13, the first spring plate 43 is subjected to a force at its end face 49 from the second step 42 of the hollow cylinder 13, which force is transmitted by way of the pressure spring assembly 45 to the second spring  
30 plate 44 and results in a displacement of the second spring plate in the direction of the second opening 18 of the hollow cylinder 13. The second spring plate 44 lies with

its end face 50 against the sleeve 48 and, due to the adjusting rod 39 being fixed locally and to the sleeve 48, is not displaceable in the direction of the second opening of the hollow cylinder 13. In this case, a further increase

5 in the control pressure in the first control pressure chamber 28 results in an additional compression of the pressure spring assembly 45 and therefore in an additional increase in the spring force, which is proportional to the further increase in the control pressure. This ensures a

10 steady displacement of the control piston 24 in the adjusting device 12, which is proportional to the control pressure difference between the first control pressure chamber 28 and the second control pressure chamber 29.

15 If the control pressure guided into the first control pressure chamber 28 is lower than the control pressure guided into the second pressure chamber 29, the control piston 24 is displaced in the direction of the first opening 15 of the hollow cylinder 13. By way of the

20 displacement of the control piston 24, and therefore the snap ring 51 integrated in the control piston 24, in the direction of the first opening 15 of the hollow cylinder 13, a force is transmitted to the second spring plate 44, which is in turn transmitted from the second spring

25 plate 44 to the pressure spring assembly 45. Since the first spring plate 43 always lies with its end face 49 against the second step 46 of the cutout 37 of the control piston 24, the compression of the pressure spring 45 assembly when there is a negative control pressure

30 difference between the first control pressure chamber 28 and the second control pressure 29 is proportional to the increase in the control pressure difference. This ensures a

steady increase in the spring force, which is proportional to the control pressure difference between the first control pressure chamber 28 and the second pressure chamber 29, and therefore a proportional displacement of the control piston 24 in the adjusting device 12.

According to Fig. 4, the axial movement of the control piston 24 along its longitudinal axis 11 is converted into a pivotal movement of the pivot balance 9 by way of a slide block 56 which is guided in a groove 57 of the adjusting device 12. The slide block 56 has a cutout (not illustrated in Fig. 4), in which a journal (not illustrated in Fig. 4) is rotatably mounted. This journal is mounted on the side face of a connecting arm 58, which is in turn fixed to the pivot balance 9. The one-dimensional axial movement of the control piston 24 in the adjusting device 12 is consequently converted into a rotary pivotal movement of the pivot balance 9 by way of a one-dimensional sliding movement of the slide block 56 in the groove 57 of the adjusting device 12 in combination with a rotary movement of the journal in the cutout of the slide block 56.